How can imitation counterbalance innovation? An ABM Bass model for competing products

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***Abstract*—The general context of this paper is the Bass model which presented a theory of the adoption of new products. We propose an agent based modelling to allow to model the respective grow of competing products. We assume that there is competition for the same market among two trademarks: each one has its own rate of spontaneous innovation and its own rate of imitation. This paper deals with the relative weight of these competing behaviours on the global dynamics; in particular, we ask the question of the equivalence between mass media influence and word-of-mouth effect.**

Keywords*—*Agent based modelling, Bass model, Marketing, Competing products

I. INTRODUCTION

The major development of the diffusion of innovation theory is attributed to Everett Rogers; in his works he indicated that the spread of a new technology depends on innovation or imitation [1]. In the seventies, Frank Bass proposed a simple model of diffusion of innovation [3][2][6] where the innovation and imitation factors shape the speed at which the technology is adopted. There are three parameters: N the market potential; p the rate of spontaneous innovation/adoption (i.e. mass media influence); q the rate of imitation (i.e. word-of-mouth effect). $A(t)$ is the fraction of customers who have adopted the product at exactly time t since introduction.

Aggregate Modelling: $A(t)$ follows the differential equation:

$$\frac{dA(t)}{t} = (p + q.A(t)).(1 - A(t)) \tag{1}$$

and the solution follows a S-shape if $(q > p)$ with $A(t)$ tends to 1 in the limit.

As the Bass model is *versatile* and allows *prediction*, it became one of the most popular in the field of marketing. For instance, table I gives parameters p and q from a cross-section representing different categories of products[1]: on average, we obtain $p = 0.03$ and $q = 0.38$ [5].

Agent Based Modelling: Following the guidelines for rigorous ABM modelling in marketing proposed in [4], we build an ABM that produces similar results to the original analytic Bass model (algo. 1)[2]. Thus, in the following, we shall be able to investigate what happens when two products compete for the same market.

[1] http://faculty.washington.edu/jdods/pdf/MktgTool_Bass.pdf

[2] To reproduce the results of the analytic Bass model, the agents are assumed to neighbour all other agents in procedure IMITATE (algo. 1).

TABLE I. PARAMETERS p AND q FROM A CROSS-SECTION OF CATEGORIES

Product	p	q	Product	p	q
Cable TV	.100	.060	VCR	.025	.603
Camcoder	.044	.304	Dishwasher	.000	.179
CD player	.157	.000	Microwave	.002	.357
Cellular	.008	.421	Hybrid Corn	.000	.797
Home PC	.121	.281	Radio	.027	0.435
Ultrasound	.000	.534	Tractor	.000	.234

II. COMPETING MODEL BASED ON AN ABM BASS MODEL

While the Bass model was initially proposed for forecasting the adoption of a new product for which no closely competing alternatives exist, we relax this constraint by assuming there is two competing products for the same market. This means that (i) initially all customers are set to the state of not having adopted none of the two products; (ii) one customers can adopt only one of the two products; (iii) the main algorithm (algo. 2) stops when all the customers have purchased one of the two products. The output of the model is the gain of P_1 relative to P_0: $g = \frac{2.V-N}{N}$ where V is the number of products P_1 adopted at the end of the run. If $(p_0, q_0) = (p_1, q_1)$ there will be as many adopted product P_0 as product P_1 and so the gain is null. If all the agents adopt P_0 (resp. P_1) then $g = -1$ (resp. $g = +1$).

We use the *NetLogo* multiagent programmable modelling environment [7]. The space is a 2-dimensional grid connected circularly and simulations are performed on a rectangular lattice composed of $N = 20000$ agents. We fix the parameters for the first product to (p_0,q_0)=(0.03, 0.38) (see tab. I)) and p_1 and q_1 will vary from 0 to 1. The question is on the influence of both innovation and imitation when a product competes with one other for the same market. To study the relation between the input parameters and the resulting gain, we draw the 3-D surface S of all the points $(p_1, q_1, g(p_1, q_1))$. To know if there is a functional relation between innovation and imitation in case of equivalent gain, we pay special attention to contour lines in S where $g(p_1, q_1)$ is constant.

Gain vs. innovation and imitation (fig. 1): (i) If innovation is high, say $p > 0.6$, the gain is close to 1; (ii) if innovation is relatively high, say $p > 0.4$, imitation has a low influence on the sales volume; (iii) if innovation is low, say $p < 0.1$, the role of imitation is significant as the gain increases with q.

Study at constant gain: Running simulations on the set of couples (innovation, imitation) such that the gain is constant results in equation $q = \alpha.ln(p) + \beta$ (fig. 2).

Algorithm 1 ABM-Bass(P)

N ▷ market potential
p ▷ coefficient of innovation for product P
q ▷ coefficient of imitation for product P
agents-own $[isAdopter_a^P]$
▷ Begin
SETUP(N, P)
GO(P, p, q)
▷ End
procedure SETUP(N, P)
    create N agents
    for each agent a **do**
        $isAdopter_a^P \leftarrow false$ ▷ $isNotAdopter_a = true$
    end for
end procedure
procedure GO(P, p, q)
    loop
        INNOVATE(P, p)
        IMITATE(P, q)
    end loop
end procedure
procedure INNOVATE(P, p)
    for each agent a with $[isNotAdopter_a]$ **do**
     ADOPT(a, P, p)
    end for
end procedure
procedure IMITATE(P, q)
    for each agent a with $[isNotAdopter_a]$ **do**
        for each (agents-on neighbors) with $[isAdopter_{an}^P]$
do ADOPT(a, P , $\frac{q}{nbNeighbor}$)
        end for
    end for
end procedure
procedure ADOPT(a, P, $probability$)
    if $randomFloat$ 1 ¡ $probability$ **then**
        $isAdopter_a^P \leftarrow true$ ▷ $isNotAdopter_a = false$
    end if
end procedure

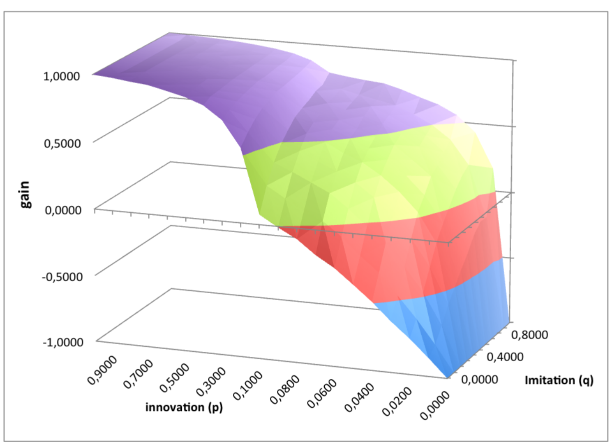

Fig. 1. Gain of P_1 relative to P_0

III. Conclusion

The question of the counterbalance between innovation and imitation is important, because answers to this question guide a

Algorithm 2 ABM-Bass-Competing(P_0, P_1)

N ▷ market potential
p_0, q_0 ▷ coefficients for product P_0
p_1, q_1 ▷ coefficients for product P_1
agents-own $[isAdopter_a^0, isAdopter_a^1]$
▷ Begin
SETUP(N, $*$)
GOCOMPETING(P_0, p_0, q_0, P_1, p_1, q_1)
▷ End
procedure GOCOMPETING(P_0, p_0, q_0, P_1, p_1, q_1)
    $t \leftarrow 0$
    loop
        $i = t \bmod 2$
        INNOVATE(P_i, p_i)
        IMITATE(P_i, q_i)
        $t \leftarrow t + 1$
    end loop
end procedure

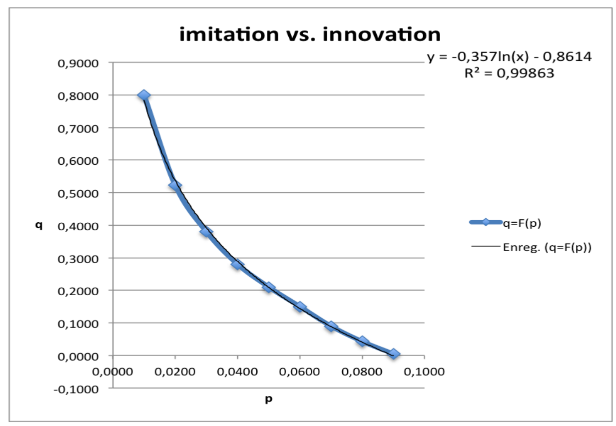

Fig. 2. Imitation as as function of innovation for $g(p, q) = 0$

firm in its deployment of resources in marketing the innovation or in favouring imitation *via* social networks. The main result is that on can counterbalance a quadratic change in innovation by a linear change in imitation.

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